Customer Profile

Cover Story

Samsung Petrochemical Company

The plant, process and product

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Samsung Petrochemical Company (SPC) has a plant located in Ulsan, Korea, a city with a major petrochemical complex. SPC produces approximately 600,000 tons of Purified Terephthalic Acid (PTA) annually and employs 470 people. The company is a multinational joint venture owned by Samsung Group of Korea, AMOCO Chemical Company of the U.S. and Mitsui Petrochemical Industries of Japan.

The product, PTA, uses paraxylene as a key raw material and is in turn used to produce polyester fiber, photographic film and video tape, beverage containers, tire coating and various electronic components. Paraxylene is made from xylene which is derived from naphtha, a crude oil derivative.

To streamline the supply of PTA, SPC operates the major production facilities at the Ulsan plant. Air compressors, crystalizers, steam turbines, centrifuges, rotary vacuum filters and dryers are some examples of rotating machinery used in the production of PTA at SPC-Ulsan.

The production process is divided between oxidation and purification steps (Figure 1). Paraxylene and oxygen from compressed air first react to make crude terephthalic acid. This oxidation reaction occurs at a high temperature (392°F or 200°C) in the presence of acetic acid and catalysts. The resulting slurry is then crystalized, centrifuged and dried to produce the yellowish white terephthalic acid powder. Crude terephthalic acid has too many impurities for polyester production, and is thus processed further in the purification step. The powder is dissolved in pure water and heated to react with hydrogen in the presence of special catalysts to remove impurities. The solution is then crystalized, where the size of particles are adjusted, separated from the liquid in a high speed centrifuge and dried to form PTA.►

Mr. Sang Jo Kim regularly uses Trendmaster®2000 Software to process valuable machinery condition data.

Fig
Producti

Agitator	Centrifuge	Centrifuge	Centrifuge	
4 points	6 points	6 points	8 points	

Gear Box
2 points

Dryer
8 points

Dryer
7 points

Dryer
8 points

Dryer
2 points

Dryer
7 points

Pump
2 points

Pump
8 points

Pump
4 points

2 points

Blower

Pump
6 points

Cooling Tower
2 points

Pump
4 points

Fig
Trendmaster® 2000

Safety is the primary concern when collecting data

The PTA process is inherently dangerous as it uses potentially explosive chemicals under high pressure and high temperature. Therefore, limiting the exposure of its personnel in these areas to lessen the possibility of an accident is SPC's highest priority.

The past: Portable data collection

Before Bently Nevada's computer-based, on-line monitoring and diagnostics systems were installed for automated data collection, SPC's maintenance engineers relied on a portable "walkaround" data checker and handheld transducers to take periodic readings manually on their rotating machinery. In addition, Bently Nevada 7200 and 9000 Series Monitors and proximity transducers were used on the critically-important process air compressors and steam turbine generator for continuous, on-line monitoring.

While the SPC engineers benefitted from the portable system, they also realized that there were safety and quality problems associated with the manual walkaround data checking program. The portable system required an extensive commitment of time and labor to check data on all points in the plant. The plant's four maintenance employees were regularly exposed to a dangerous environment near operating machinery. This increased the risk of possible on-site injury. In addition, the accuracy of the data collected by the portable system was not consistent due to variations in the position, pressure
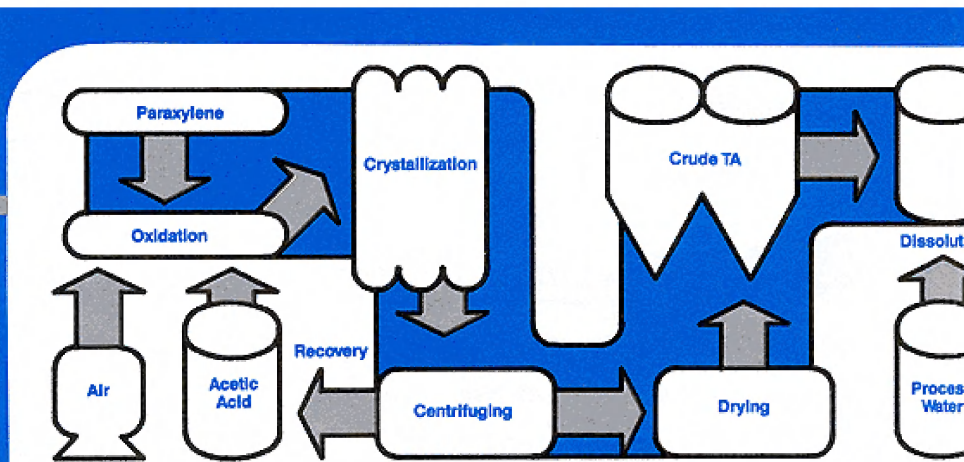
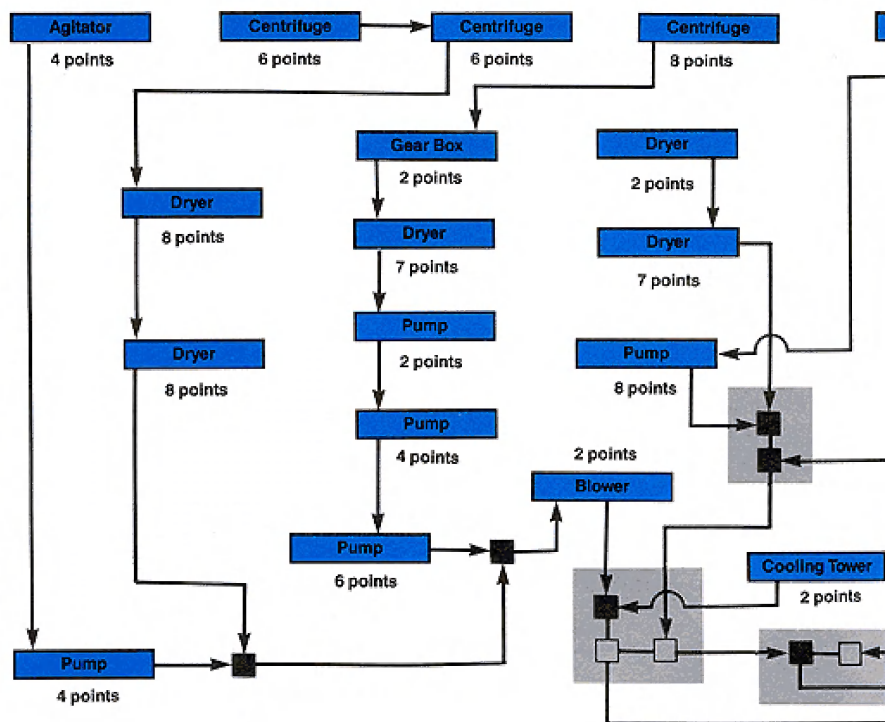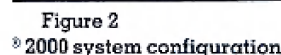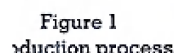and the placement angle of the handheld transducer. Since it was seldom feasible to take readings more often than once a day, it was also possible to miss important machine events which occurred between readings.

As recognized innovators and leaders in the industry, SPC engineers clearly felt the need for a new approach to their predictive maintenance program which addressed the aforementioned concerns in a cost-effective manner.

The present: Computerized, on-line monitoring

Samsung uses a Trendmaster®2000 System (TM2000) to monitor noncritical rotating machinery. The TM2000 is an on-line system which periodically samples, processes and trends data on SPC's blowers, centrifuges, dryers, reactors and pumps. Critical machinery, which includes Samsung's three process compressors, and one steam turbine generator, are monitored by a more

Figure 1
Production process

Transducers	Nov. 1990	Aug. 1991	Total
Horizontal	9	45	54
Vertical	7	49	56
Motor Horizontal	0	28	28
Motor Vertical	0	8	8
Total	16	130	146

System Expansion

Figure 2
2000 system configuration

advanced Bently Nevada Dynamic Data Manager™ (DDM) System. The DDM is designed for continuous, on-line monitoring on machines with fluid-film or rolling element bearings. The DDM System will be described in greater detail later in this article.

Periodic on-line monitoring: Trendmaster® 2000 installation

In order to improve SPC's predictive maintenance program and address the shortcomings of the portable system,

Bently Nevada Korea, a wholly owned subsidiary of Bently Nevada Corporation, introduced TM2000 to SPC in late 1990. This computerized, on-line machinery information system was used to collect data on SPC's general-purpose machines. Unlike conventional systems, the TM2000 uses an advanced "single-cable" architecture which minimizes installation wiring cost. Low-cost, permanently-mounted transducers are used on each point where data is required.

SPC decided on an initial installation of sixteen machinery points with velocity transducers mounted on the bearing housings of a centrifuge, pump gear box, agitator, motor, blower and centrifugal pump. This test installation was completed in November 1990. SPC maintenance personnel handled the majority of the installation; Bently Nevada Korea engineers aided in the system design.

During the test period, SPC engineers became convinced of the overall value of the TM2000 System. Subsequently, SPC decided to expand the TM2000 by adding 128 more velocity points on other machines, including cooling towers, dryers and additional pumps and motors. This system expansion was completed in August 1991. Since a single, standard TM2000 System can accommodate up to a total of 2040 points, SPC plans to gradually expand its system by adding more points as money becomes available. Currently, 144 points are connected to the TM2000 System. Figure 2 illustrates the TM2000 System configuration at SPC.

SPC's TM2000 System consists of:
- Velocity Transducers
- Velocity Transducer Interface Modules (TIMs)
- TIM Housings (rated NEMA 4X)
- Cable T-Connectors (to split the system cable in two directions)
- System Cable
- Line Extenders [for cable runs longer than 4000 feet (1200 metres)]
- Signal Processing Adaptor (SPA) Boards (installed in the expansion slots of the system computer)
- 386 Desktop Computer System
- TM2000 Software
- Printer

TM2000 detects pump and centrifuge problems

The TM2000 System, currently based in the maintenance department office, has already produced positive results. ►
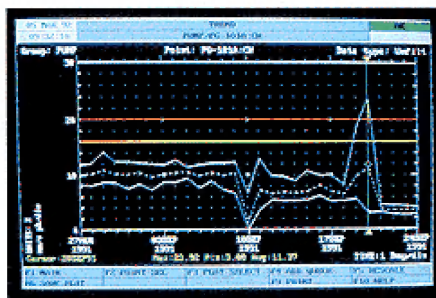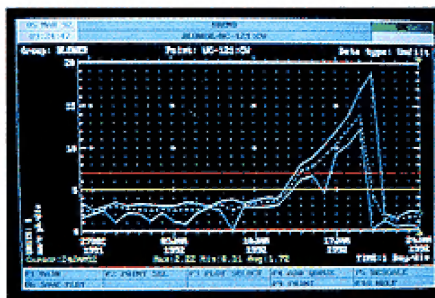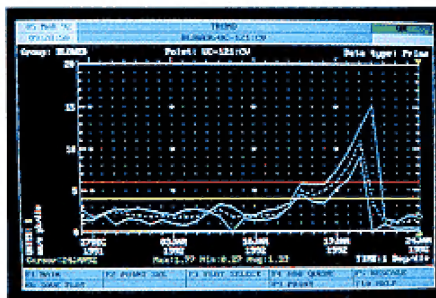
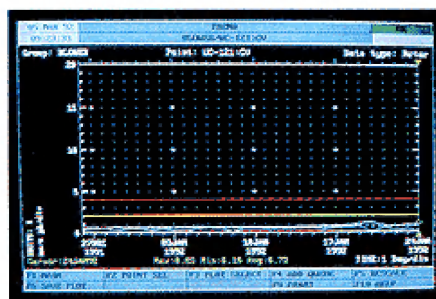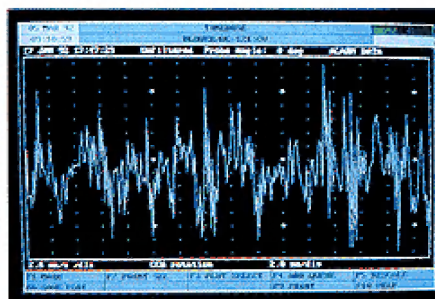# Customer Profile

Samsung Petrochemical Company

Figure 3
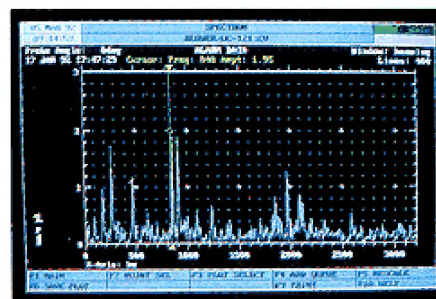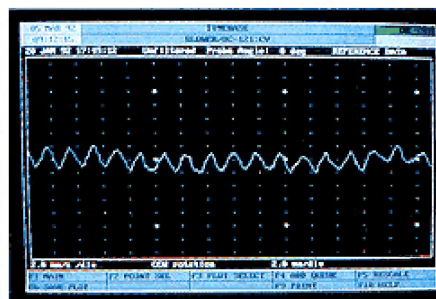
Figure 4

Figure 5

Figure 6
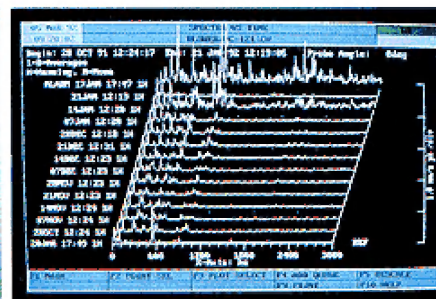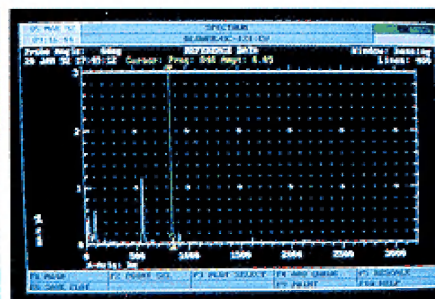
Figure 7a and 7b

Figure 8a and 8b

Figure 9

On 20 September 1991, the TM2000 System successfully detected a rub between the impeller and the casing on the PG101A centrifugal pump which was operating at 1800 rpm. The problem was detected when the vibration level increased above the alarm limit, causing a visible and audible alarm on the computer. The frequency spectrum plot (Figure 3) during the alarm event indicated higher than normal vane passing frequency component vibration. When the unit was inspected, a slight rubbing trace was discovered on the impeller vanes and the casing. Information from the TM2000 enabled SPC's engineers to repair the unit before major damage occurred.

The system also detected an imbalance problem at an early stage on the TM502A centrifuge rotor caused by a lump of process material stuck to part of the rotor. This problem could have resulted in major damage to the machine if not detected at an early stage.

Machine save on a blower

On 13 January 1992, SPC's TM2000 System initiated an audible and visible system alarm which notified Samsung that a velocity transducer on their UC-121 blower was detecting an alarm condition. An unfiltered trend plot verified that increasing vibration was occurring at that point (Figure 4). SPC engineers then requested a filtered trend plot which indicated that the alarm was due to the amplitude increase in the Prime Spike region (Figure 5). However, trend data in the rotor region indicated virtually no change in amplitude (Figure 6).

After reviewing this trend data, along with dynamic data provided by the TM2000 System, such as a Timebase plot (Figure 7) a Frequency Spectrum, (Figure 8) and a Spectra versus Time plot (Figure 9), SPC's engineers concluded that the alarm was due to a failing rolling element bearing.

Due to high output demands, SPC had to wait until 19 January to replace the bearing. After the bearing was replaced, the vibration level returned to

a normal level, as indicated on the Trend and the Reference Data Plot Comparisons (Figures 5 & 7).

Due to the capability of the TM2000 System, SPC's engineers were not only able to detect the machine problem at an early stage, but also to diagnose its source. Therefore, they could schedule the repair work according to their plant load requirements and the severity of the problem.

SPC continues to use the following features and displays of the TM2000 System to detect possible machinery problems in their plant:

- Current Value readings
- Trend plots (unfiltered & filtered)
- Timebase plots
- Frequency Spectrum plots
- Frequency Spectra versus Time (Waterfall) plots
- Multiple plot comparison
- Multiple alarm level settings per point
- Up to 400 most recent alarm events list
- Visible and audible computer alarm annunciation
- Automatic storage of dynamic data upon alarm
- Reference data storage and display

Continuous on-line monitoring Dynamic Data Manager™ System

SPC also operates several large critical machines including three process compressors and one steam turbine generator. These are continuously monitored by Bently Nevada 7200 and 9000 System Monitors and proximity probe transducers. These on-line vibration protection systems provide Alert and Danger alarms which can shutdown the machine if high vibration exceeds a setpoint.

In the past, in order to diagnose the causes of high vibration, it was necessary to set up portable diagnostic vibra-

tion equipment to record and analyze the data. This was a potentially dangerous situation. This "after-the-event" process was also time-consuming, and it was often difficult to diagnose a malfunction due to lack of pertinent dynamic data before and during the alarm event.

The DDM System, used in conjunction with SPC's existing monitoring systems on large critical machinery, provides a sound solution. The DDM is a computerized, on-line monitoring and diagnostics system that collects, stores and displays continuous steady state dynamic and static vibration data from critical rotating machinery. A unique feature of the DDM is its ability to freeze and store current steady state dynamic data upon an Alert or Danger alarm condition. This information can be retrieved for analysis immediately or at a later time.

The DDM System and the TM2000 System were installed at the same time in August 1991 during a scheduled plant outage. Figure 10 illustrates the configuration of the DDM System installed at SPC. Since the transducers and monitor racks were already in place except for the Keyphasor® probes, it was a relatively easy task to install the system. The system installation involved the following steps:

1. Install a Keyphasor probe and mark a Keyphasor notch on each shaft.
2. Install DDM Communications Processors (CPs) near the monitor racks (each monitor rack requires one CP).
3. Install the RS422 cables connecting CP to CP to the system computer in series.
4. Configure the system software according to the machine trains and transducer locations.

Two process air compressor units (TC-101/102 and BC-101/102) are currently connected to the DDM System. Since the current DDM System can ▶
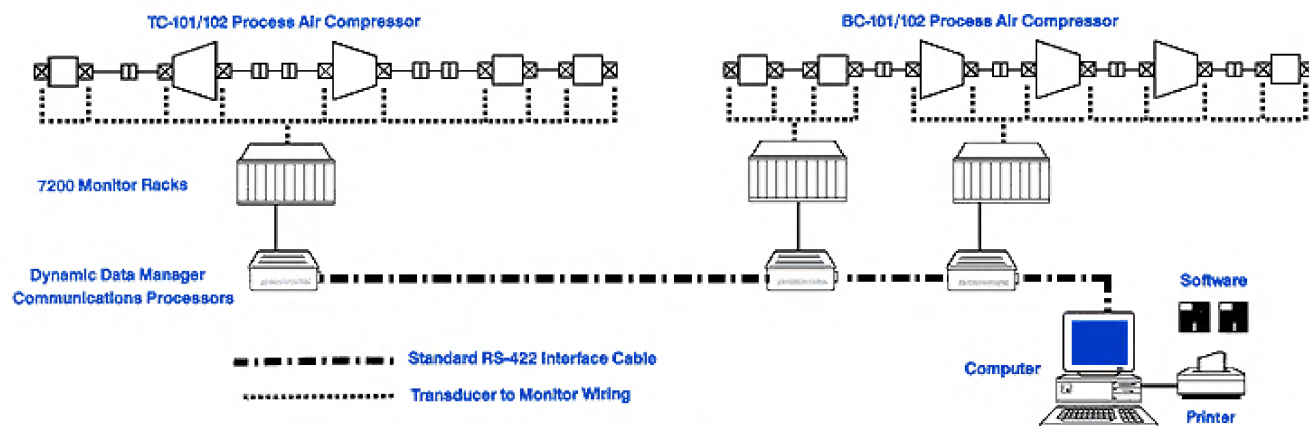
Figure 10
Dynamic Data Manager™ System

accommodate up to twelve monitor racks or CPs, SPC plans to later expand the DDM to include the remaining process air compressors and the turbine generator set.

SPC uses the following DDM System displays to diagnose dynamic and static vibration data:

- Current Values (overall values, probe gap voltages, 1X filtered amplitudes and phase lags, OK and alarm status and shaft rotative speeds).
- Bar Graph (meter representation of current values for each point).
- Trend plot (overall values, filtered amplitudes and phase lags, probe gap voltages).
- Acceptance Region plots (the trend of 1X or 2X vibration vectors in Polar format).
- Orbit/Timebase plots
- Shaft Centerline plot (average shaft position)
- Frequency Spectrum plot
- Alarm Event List (up to 200 entries)
- System Event List (up to 150 entries)
- Shift Report (summary of data and events)
- Reference Data

SPC is also pleased that the DDM System can automatically save dynamic data on alarm and annunciate the alarm audibly and visually to maintenance personnel.

Training is the key to success

With the combined TM2000 and DDM computerized system capabilities available, SPC believes it is important to develop in-house technical expertise in the area of machinery vibration monitoring and diagnostics in order for the program to be effective. As one of the staff training programs, SPC maintenance engineers attended the Bently Nevada Machinery Diagnostics Seminar offered in Minden, Nevada, U.S.A., during October 1991. Training will also be extended to plant operators as SPC plans to install an additional computer system in the control room. This will provide plant operators with on-line vibration information 24 hours a day. Currently, both the TM2000 and DDM System computers are located in the maintenance department office only.

Information from these systems will eventually be integrated into SPC's Maintenance Management System (MMS). Originally developed by Hewlett Packard, the MMS is a plant-wide database system that helps SPC efficiently manage its plant, from procurement to equipment maintenance.

Using the MMS, the Condition Base Management concept derived from TM2000 and DDM data will be coupled with the Time Base Management concept based on Mean Time Between Failure calculations. The objective is to provide plant operators and maintenance personnel with a logical set of instructions on what actions should be taken when faced with machinery problems.

SPC constantly strives for improvement

Mr. Hae Won Lee, Mechanical Section Chief, Mr. Sang Jo Kim and their co-workers were all instrumental in the TM2000 and DDM System installation. SPC's staff is extremely pleased with their Bently Nevada computerized vibration information systems. Having these systems on-line has increased their confidence in SPC's plant operation and maintenance. In an increasingly competitive business environment, where efficiency and safety of plant operation are the key factors, SPC is clearly an innovator in the field of predictive maintenance. SPC does more than merely display the slogan "Technology is the Energy of the Future" on their Ulsan facility. They actively practice this philosophy. ▣